APS Upgrade Overview and Status

Stuart Henderson
Director, APS Upgrade Project

APS Users Organization/Partner User Council Joint Meeting
January 28, 2015

Outline

- Moving the Project forward
- Project status
- Beamline scope in the upgrade and APS Planning

Moving the Project Forward – Four Elements

- Develop the Mission Need
  - unique features of the upgrade, the science that it will enable and the urgency associated with moving it forward
- Articulate the Science Case
  - community's articulation of visionary science and mind-blowing possibilities
  - community engagement and support
- Develop, refine and prove the concept through the R&D Program
  - progressing on critical R&D and prototyping
- Develop and validate the Project to get ready for CD-1
  - establish CD-1 readiness
  - external validation of the APS-U approach, challenges, solutions and readiness

Developing the Mission Need: Meeting with DOE – March 5, 2015

- We spent the Fall assembling a Mission Need-style presentation and iterating on the material with BES
- Stefan Vogt has been tasked with advising on and coordinating technical activities related to Science Case
- We have a meeting scheduled for March 5, 2015 in Germantown to finalize information needed to move the project forward.
- For that meeting we are preparing
  - Final "Stump Speech" (a.k.a. Mission Need) Presentation
  - A set of 12 whitepapers answering 49 Tough Questions
    - 6 complete, 4 in draft, 2 in progress
  - Firmed up agreement on scope, target TPC and funding profile
- Our understanding is that following the successful outcome of the March meeting:
  - CD-0 will be revised to incorporate new scope, cost and schedule
  - We will begin planning a CD-1 review, scoping out late summer time frame

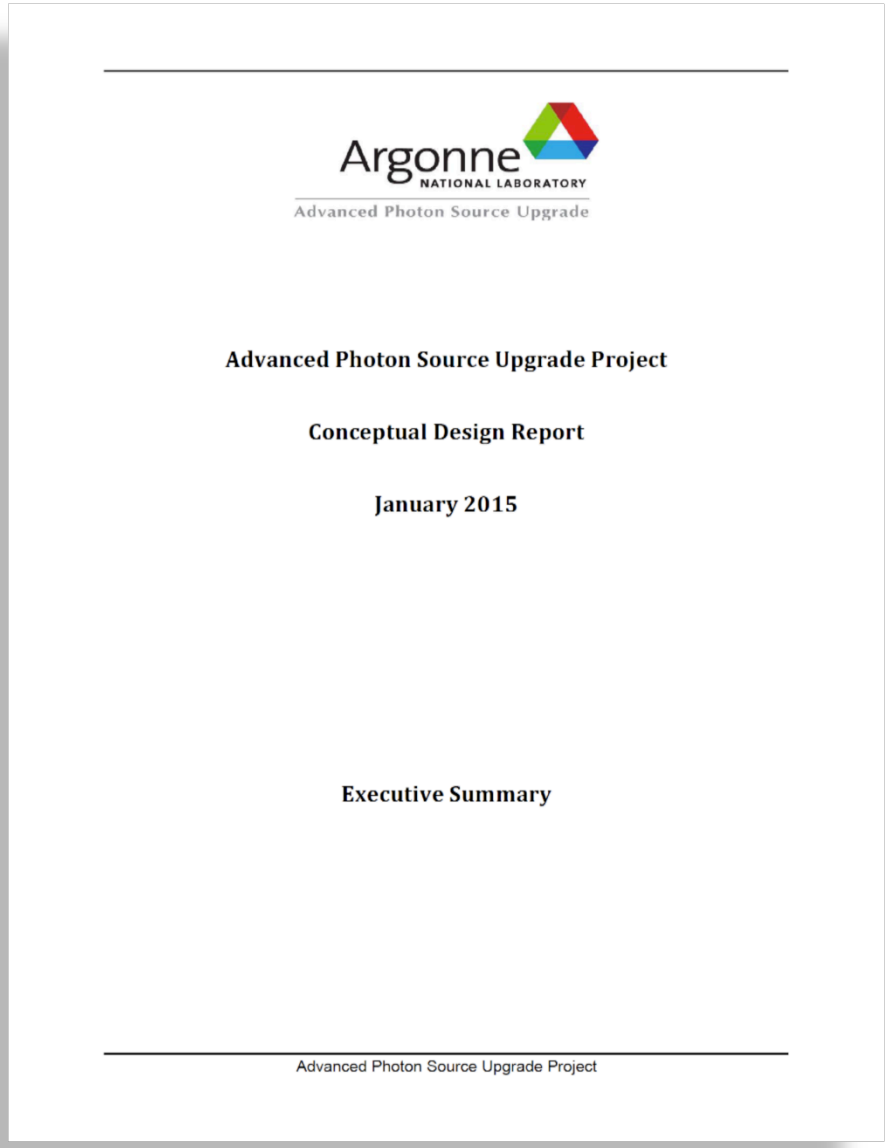
Path Forward: Science Case

- We have been encouraged by DOE to organize a community-based process to deliver a “First Experiments”-type document
- We are formulating this process to deliver on the BESAC recommendation:
  - July 2013 BESAC Report: “…recommendation for a new U.S. light source facility should not be based on capacity issues, but rather on **science-driven needs** for new and unavailable photon characteristics that would allow users to **carry out previously impossible grand challenge experiments**”
- Paul Evans (U. Wisconsin) has agreed to help organize the scientific planning process, co-chairing this activity with Stephen Streiffer.
- We envision a number of working groups which will begin forming in January, leading to a series of focused workshops (in April) culminating in a draft “First Experiments”-type document (in June)
- We hope that this process spurs excitement and enthusiasm within the user community for the Upgrade, helps to show that it is real and gaining momentum, and spurs excitement for the scientific possibilities enabled by the source

Path Forward: Getting "CD-1 Ready"

- We have completed a draft Conceptual Design Report
- We have formed an APS Machine Advisory Committee (MAC) to provide technical advice
- The first MAC meeting is Feb. 2-4, 2015:

  https://apsshare.aps.anl.gov/apsu/ProjectReviews/MAC_201502/Pages/Agenda.aspx
- Our goal for this meeting is to get external validation from a group of the world's experts on the APS-U accelerator concept
- A requirement for CD-1 approval is to have an external independent review of the conceptual design


Argonne NATIONAL LABORATORY
Advanced Photon Source Upgrade

Advanced Photon Source Upgrade Project

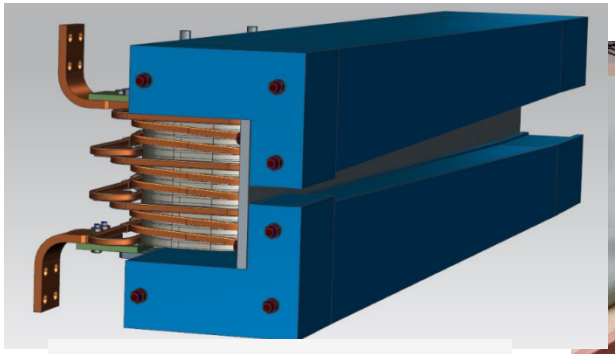
Conceptual Design Report

January 2015

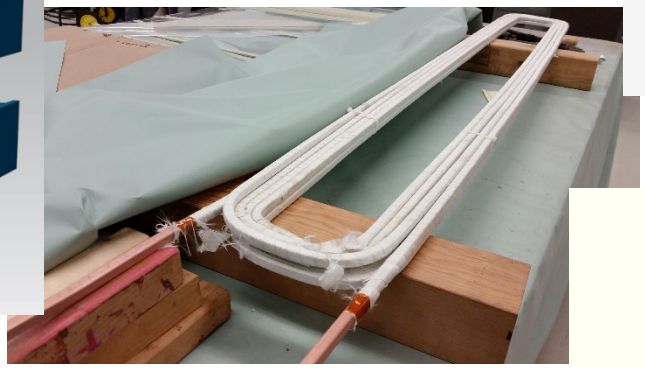
Executive Summary

Advanced Photon Source Upgrade Project

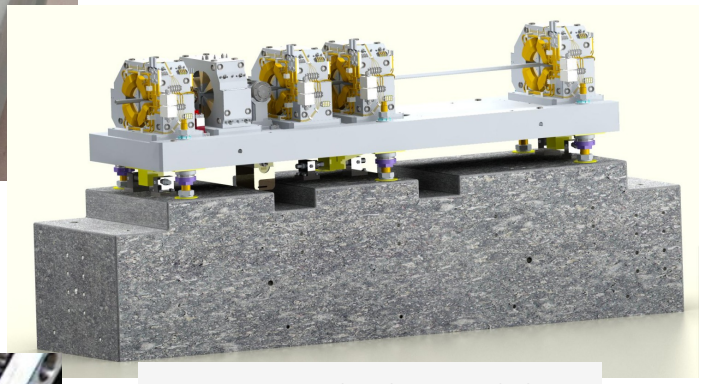
Path forward: making good technical progress through the R&D Program



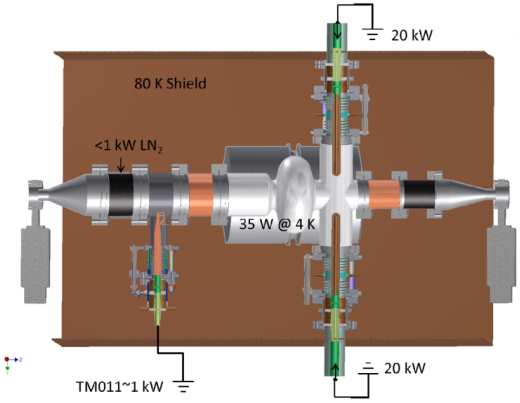
Longitudinal gradient dipole concept



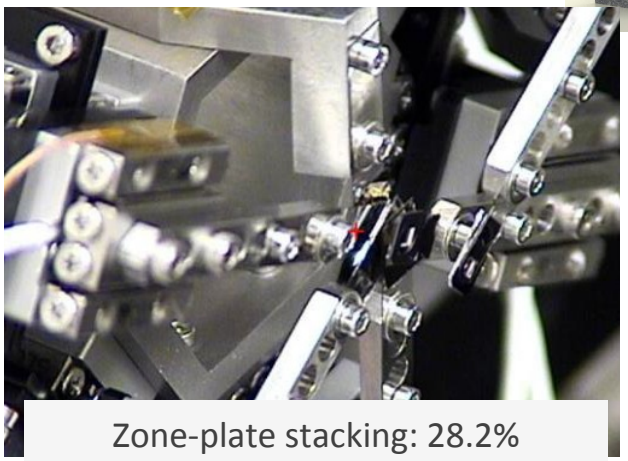
First gradient dipole wound coil



Demo multiplet module



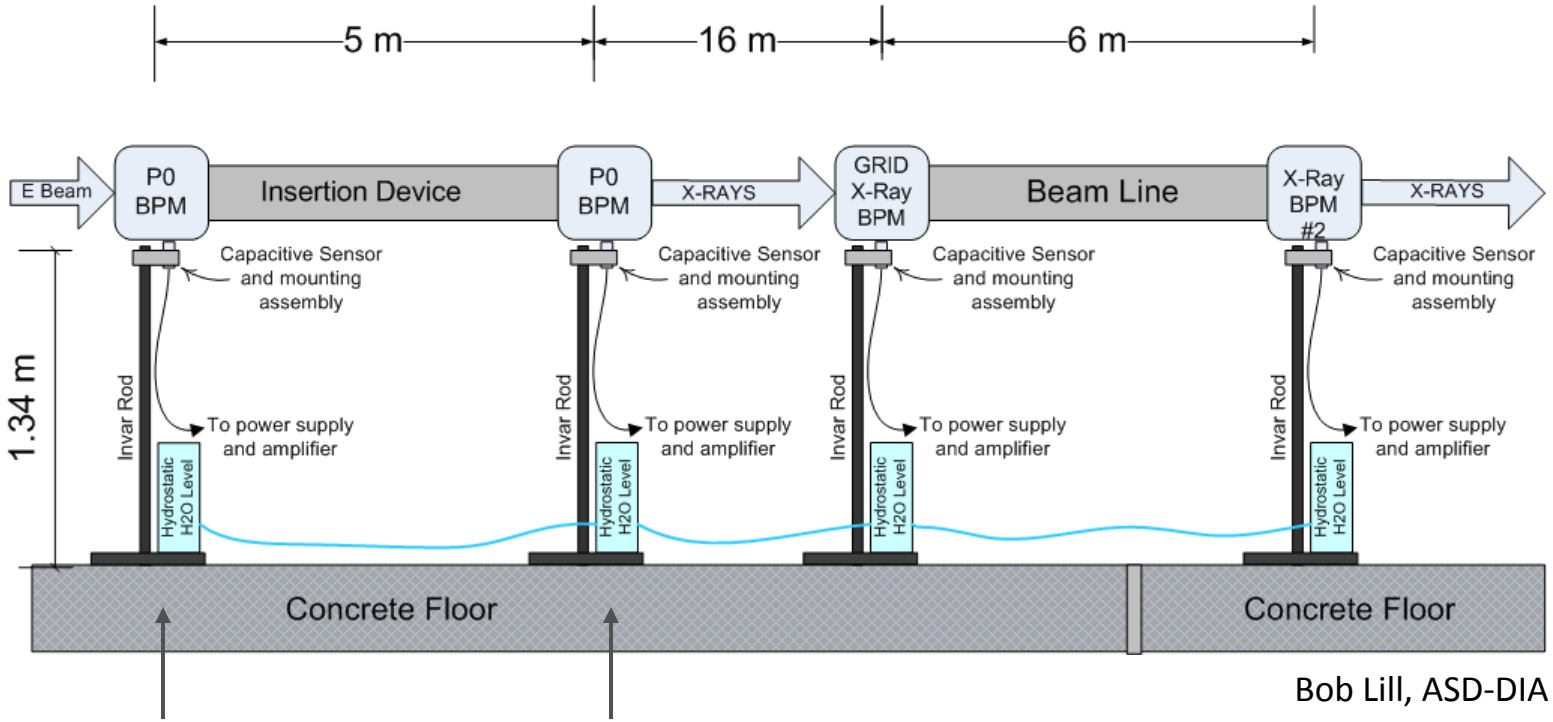
High harmonic cavity for bunch lengthening



Zone-plate stacking: 28.2% efficiency at 27keV using intermediate field stacking of 6 ZPs

Steel sub-frame for the multiplet concrete plinth at Corsetti Steel

Mechanical Motion Monitoring System R&D – Sector 27



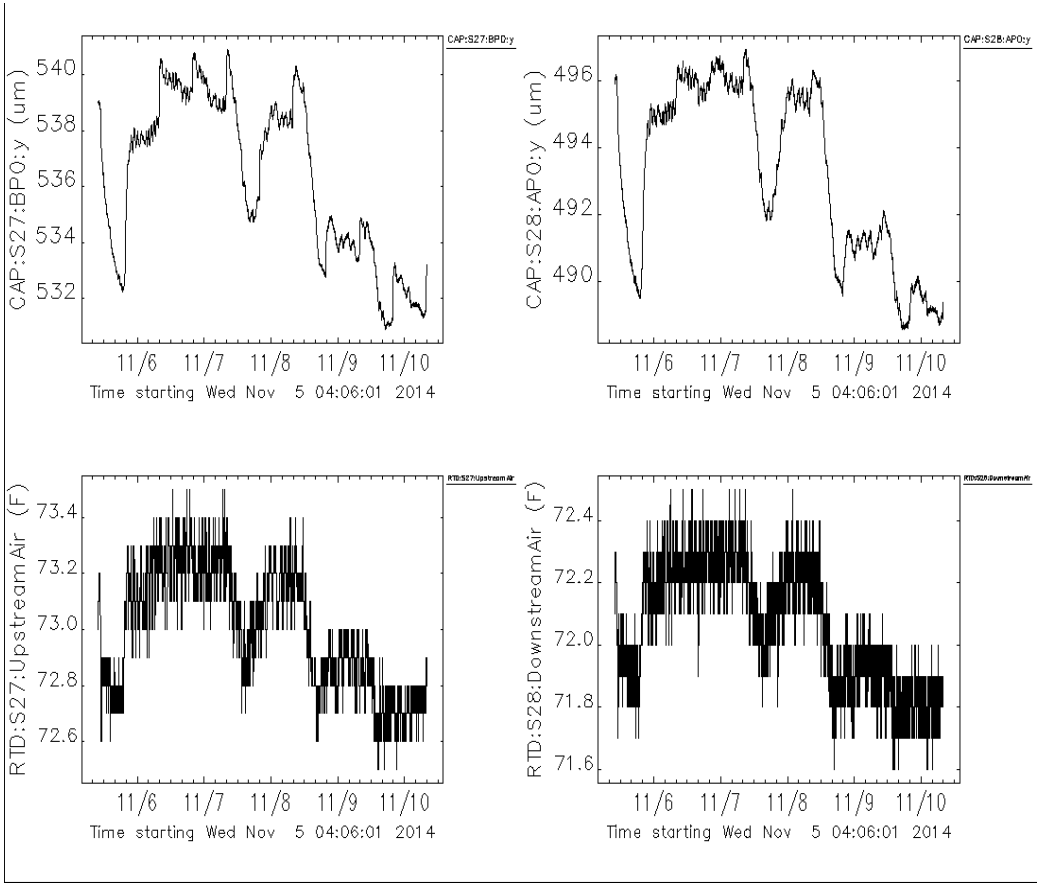
Bob Lill, ASD-DIA

- Hydrostatic level sensors monitor vertical floor motion.
- Capacitive proximity sensors monitor motion of RF BPMs relative to the floor.
- Both systems have resolution at the level of tens of nm or better.
- Presently, only the P0 rf BPM pickup electrodes are instrumented.

ID Vacuum Chamber Motion in Sectors 27 and 28

ID Vacuum Chamber measurements at Sector 27 (left) and Sector 28 (right) shown for ~week of 5 November

- 8 micron / deg F vertical motion agrees well with calculation based tunnel temperature and effect on mechanical supports
- Effect on BPM position under review—relative motion of BPM to beam could be misinterpreted as beam motion



APS Upgrade Project Scope

- Accelerator
  - New 6 GeV MBA high-brightness storage ring lattice in existing tunnel
  - Doubling of ring stored beam current to 200 mA
- New insertion devices for 35 sectors optimized for brightness and flux
  - Incorporates SCUs on selected beamlines
- New and upgraded front-ends of common design for maximum flexibility
- Beamlines
  - A suite of 3 new and 3 upgraded beamlines designed for best-in-class performance with high-brightness source
  - Optics for remaining beamlines to take full advantage of MBA source properties
- Improved electron/photon beam stability

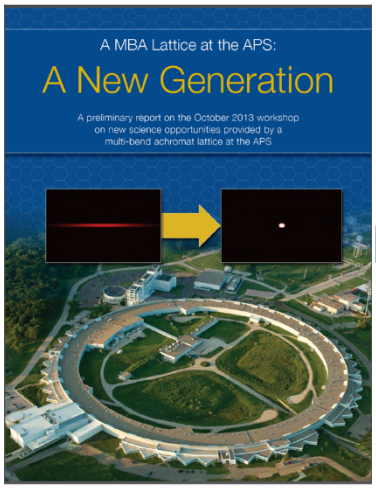
All beamlines will realize significant benefits

- **Well-defined** installation and testing period is a **key deliverable**
  - **External review found the present ~12-month plan achievable**
  - Given the importance of minimizing APS unavailability, the APS Upgrade will require a very different strategic approach from typical installations
  - We have performed a thorough survey of installation/commissioning experience

Proposed Beamline Scope in the Upgrade

- There are four elements of project beamline scope which must eventually be baselined
- At present these have only been evaluated in a generic sense for costing purposes:
  - New beamlines (3 included for costing)
  - Beamlines which receive major upgrades (3 included for costing)
  - Beamlines which receive minor upgrades (a ~$42M package of optics and detector improvements included for costing)
  - Insertion devices: assumes a number of superconducting undulators, reworked PM undulators to account for reduction in storage ring energy, revolver undulators and so on, for costing
- It is worth pointing out that the cost for beamline technical scope in the present formulation of APS-U is similar to that in the previous formulation
- All ID beamlines will have new and/or upgraded front-ends (HHLFE), including next-generation (“GRID”) x-ray bpm system, etc.
- All beamlines will benefit, but choices will have to be made on new beamlines, major upgrades, minor upgrades and ID selection

The Big Picture: *APS-U Project View*



Described broad scientific opportunities enabled by an MBA upgrade to APS

Grand Challenge Experiments at the Upgraded APS

Describes a set of grand challenge experiments and their potential implementation at APS-U

Integrated Plan for APS-U and beyond

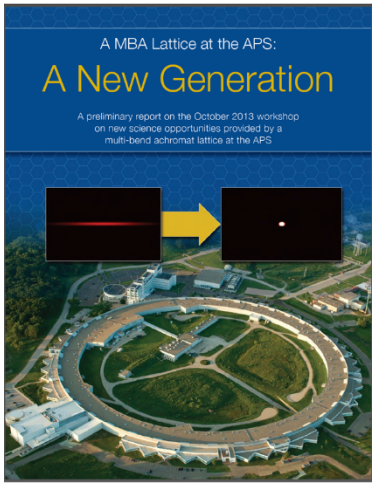
Describes the long-term plan for development at APS

APS-U project scope

The Big Picture: *Complete View*

Near-Term Improvements

APS 5- Year Facility Plan/Strategic Plan



Grand Challenge Experiments at the Upgraded APS

Integrated Plan for APS-U and beyond

APS Ops funded investments

APS-U Project Scope

Follow-on beamline project?

Partner funded beamlines

Partner Strategic Plans

Community Participation

Other News

- The “Upgrade Forum” begins this week
  - This is a forum to fill a need that exists for discussion, presentation, brain-storming around upgrade topics of interest to the scientific community
  - Dean Haeffner and Stefan Vogt are organizing it
  - This is the principal forum for interaction between the user community and project, at a grass-roots and informal, i.e. non-management, level

- APS-U FY15 Funding is as expected
  - Received additional funding in the next financial plan, consistent with $20M in FY15
  - Expecting flat funding in FY16

Recent and Upcoming Events and Workshops

- Recent Workshops
  - *Diffraction Limited Storage Ring Workshop*, Nov. 19-21, 2014
  - *Full Field Imaging*, Jan 20-21, 2015

- Upcoming Events
  - *Upgrade Forum, 10:00 Thursday January 29, 2015, A1100*
  - *MAC February 2-4, 2015*

- Upcoming Conferences and Workshops
  - *APS SAC Meeting March 18-19, 2015*
  - *Twenty Years of the APS, March 26, 2015*
  - *IPAC 2015, May 3-8, 2015*
  - *SRI, New York, July 6-10, 2015*
  - *Denver X-ray conference, Aug. 3-7, 2015*

Finally….

- Your advice and support are extremely important to us
- We are about to launch the next phase of the Science Case planning process for APS-U and look forward to your support and involvement in that process
- We will be counting on your support as we continue to make the case that an upgraded APS is an essential 21st century tool for 21st century science

Backup

Comparison of APS-U to other light sources worldwide in early 2020s

Parameter		APS	APS Upgrade		ESRF-II	SPring8-II	Petra-III	NSLS-II	MAX-IV	Sirius
		Present	Hi-Bright	48 Bunch						
Energy [GeV]		7	6	6	6	6	6	3	3	3
Current [mA]		102	200	200	200	100	100	500	500	500
Emittance, Horizontal [pm]		3113	67	48	142	99	1000	800	302	275
Brightness (*)	8 keV	1	88	51	61	43	4.1	3.7	13.9	22.7
	20 keV	1	336	144	164	137	2.9	0.8	5.2	8.1
	80 keV	1	382	152	154	127	1.0	0.01	0.4	0.3
Flux Density (*) (#)	8 keV	1	4.6	4.1	3.9	1.8	1.8	0.4	2.0	1.7
	20 keV	1	10.4	9.1	7.7	4.1	1.4	0.1	0.6	0.5
	80 keV	1	10.4	9.0	7.5	3.9	0.1	0.0	0.0	0.0
Coherent Flux	8 keV	9.3	813	472	562	398	38	34	129	211
(10^{11} ph/s)	20 keV	0.6	198	85	97	81	2	0	3	5
Single Bunch Brightness @ 8 keV (*)		1	6.5	25.5	1.5	5.1	0.3	0.1	1.9	3.1
Flux for 10 nm focus @ 20 keV (*)		1	336	144	164	137	2.9	0.8	5.2	8.1

(*) Relative to present APS performance

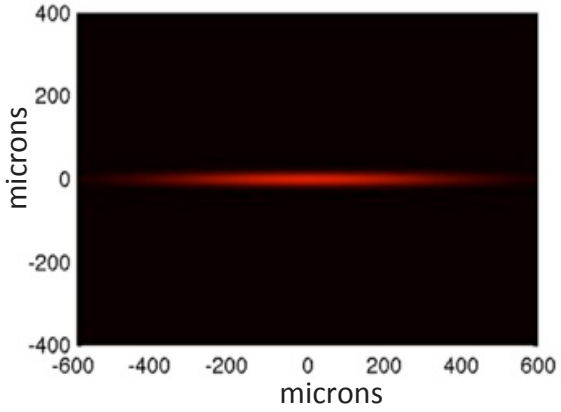
(#) Flux Density is through a 0.5 x 0.5 mm aperture at 30 m

No light source now operating or under construction can match all of APS-U's technical capabilities

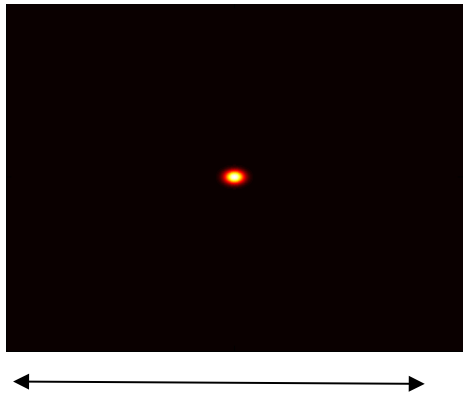
Implementation of an MBA lattice and optimized IDs dramatically enhances APS performance as a hard x-ray source

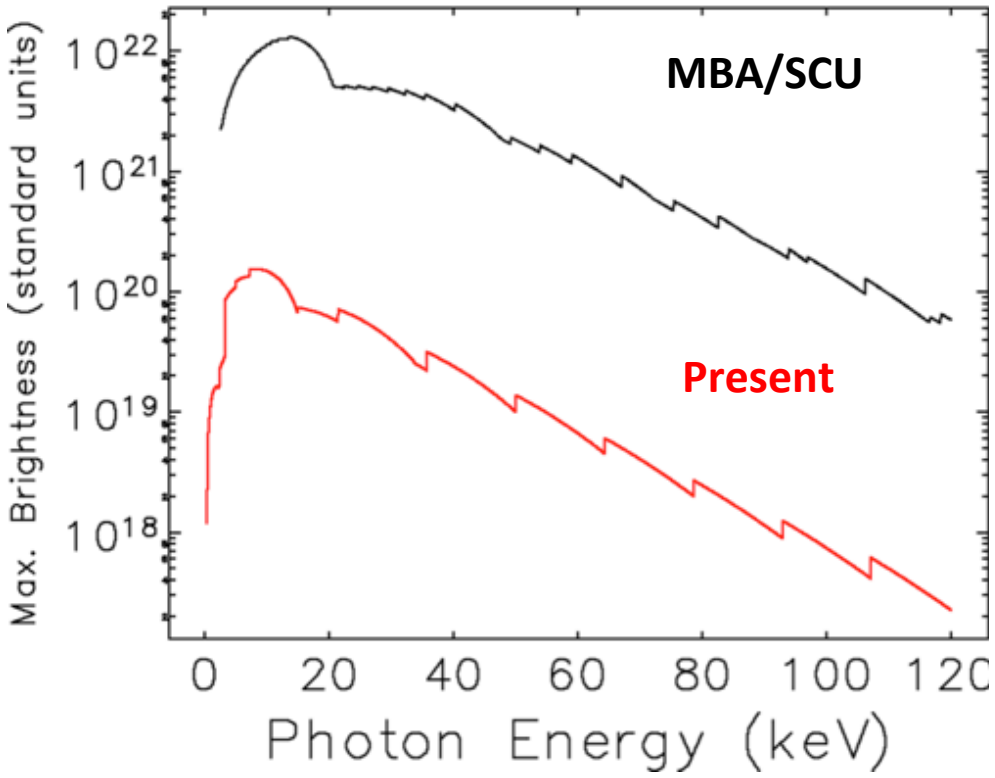
Particle Beam Profiles

APS Now



APS MBA



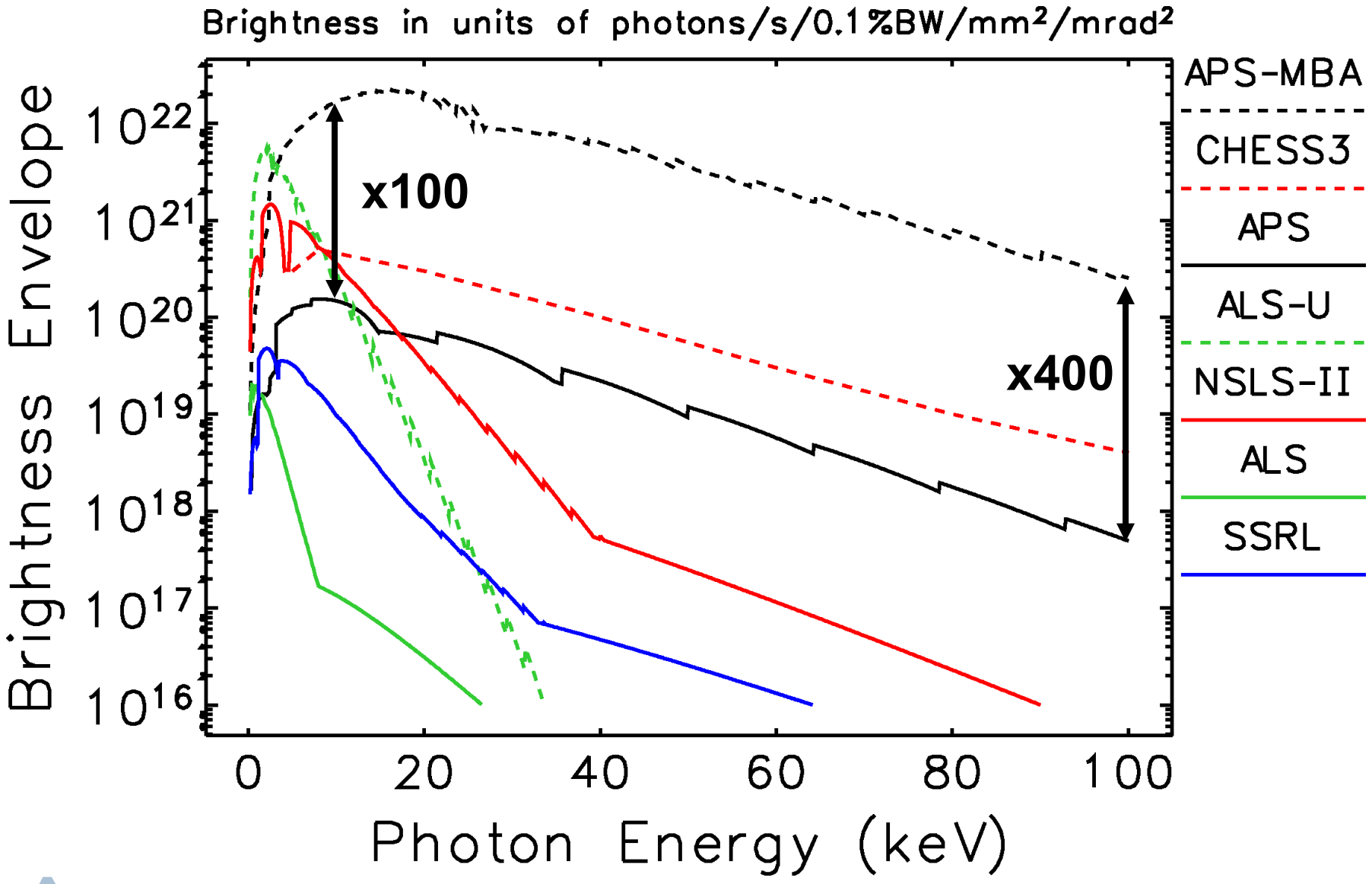


Parameter comparisons: APS today vs APS MBA Upgrade*

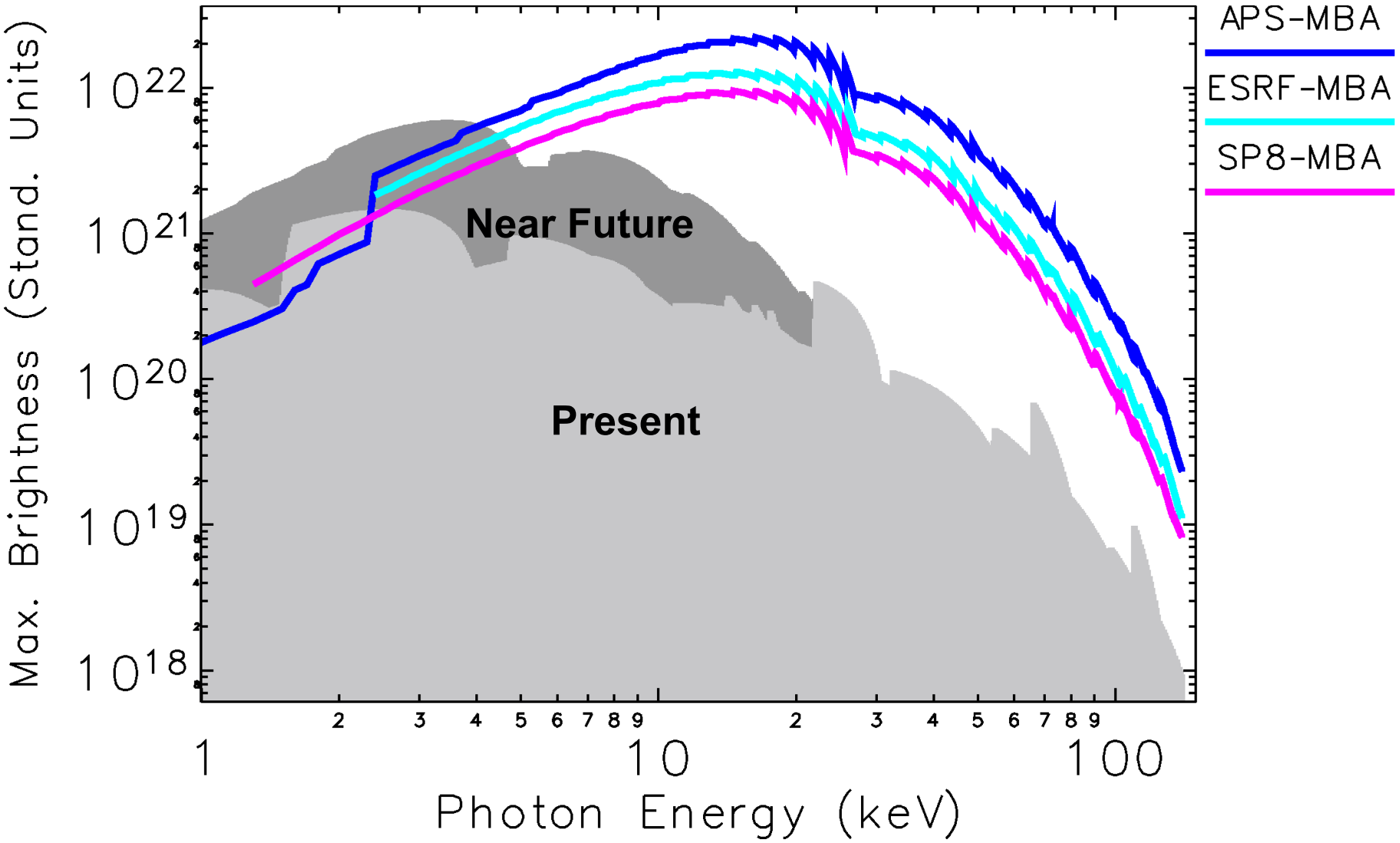
Quantity	Symbol	Units	APS Now	APS MBA Timing Mode	APS MBA Bright. Mode
Beam Energy	E	GeV	7	6	6
Beam current	I	mA	100	200	200
Number of bunches	N_b		24	48	324
Bunch duration	σ_t	ps	34	70	18
Bunch spacing	T_b	ns	153	77	11
Bunch rep. rate	f_b	MHz	6.5	13	88
Emittance ratio	$\kappa = \epsilon_y / \epsilon_x$		0.013	1.0	0.1
Horizontal emittance	ϵ_x	pm	3100	46	65
Horizontal beam size	σ_x	μm	275	17.8	21.2
Horizontal beam divergence	$\sigma_{x'}$	μrad	11	2.6	3.1
Vertical emittance	ϵ_y	pm	40	46	7
Vertical beam size	σ_y	μm	10	10.2	4.0
Vertical beam divergence	$\sigma_{y'}$	μrad	3.5	4.3	1.6

*H7BA-TwoSector-nux95-nuy36-3PW-Version4
Courtesy M. Borland

APS-U within the present and future domestic context



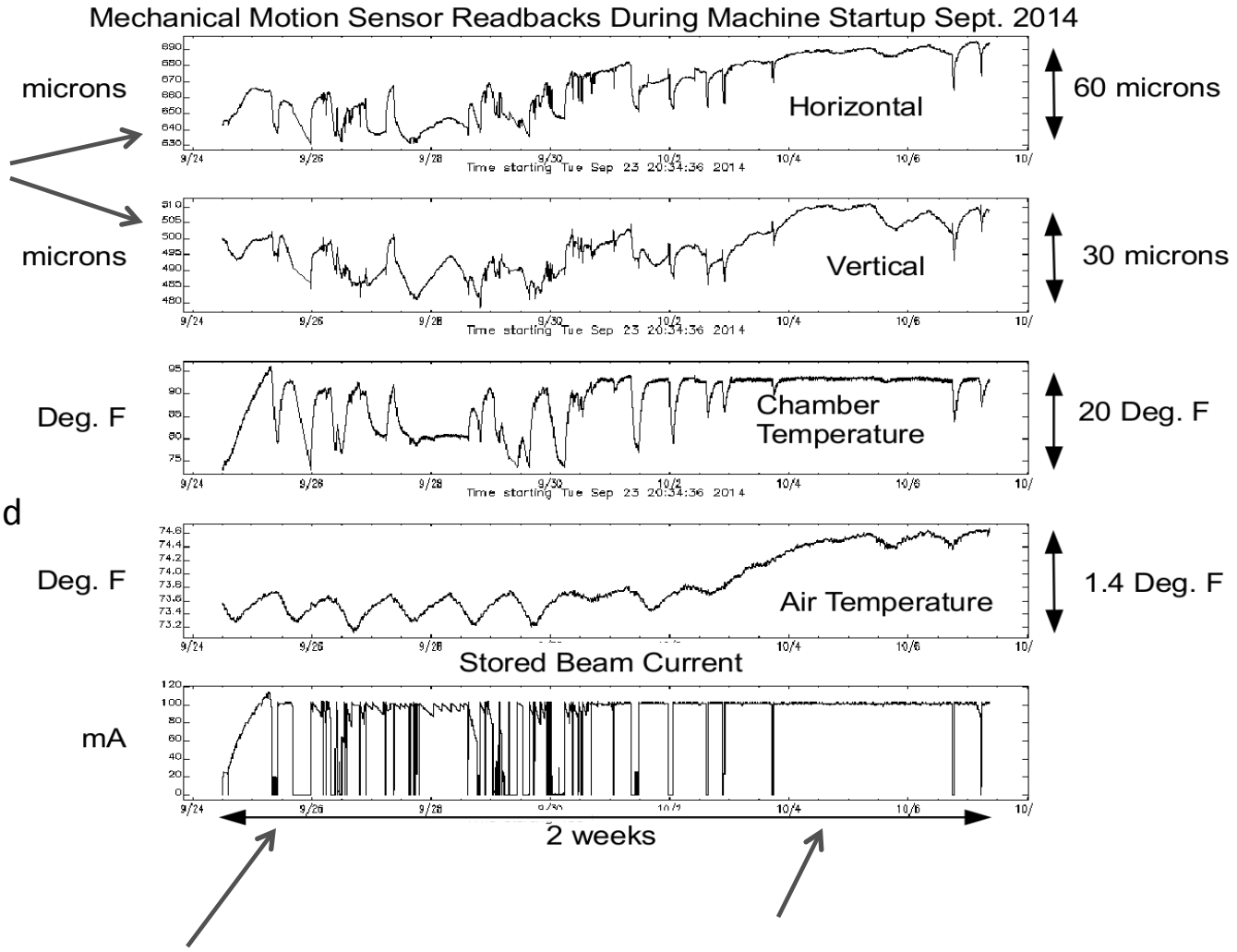
APS Upgrade delivers world-leading performance



Capacitive Sensor Data

Mechanical position of 27-ID vacuum chamber pickup electrodes

Motion influenced by both air temperature and beam heating



Significant motion seen during machine startup period.

Much more stable during top-up user beam operation